Pedagogical Research
2025, 10(1), em0231
e-ISSN: 2468-4929
https://www.pedagogicalresearch.com

MODESTUM

Research Article **OPEN ACCESS**

Utilizing educational robotics in elementary school to foster problem-solving skills and enhance the teaching of history

Kalliopi Aslanoglou [1], Nikolaos C. Zygouris [2*], Stella Tsermentseli [3], Eleftheria Beazidou [4], Apostolos Xenakis [5]

[1] Department of Electrical and Computer Engineering, University of Thessaly, Volos, GREECE
[2] Digital Neuropsychological Assessment Laboratory, Department of Informatics and Telecommunications, University of Thessaly, Lamia, GREECE
[3] Department of Primary Education, University of Thessaly, Volos, GREECE
[4] Department of Special Education, University of Thessaly, Volos, GREECE
[5] Department of Digital Systems, University of Thessaly, Larisa, GREECE
*Corresponding Author: nzygouris@uth.gr

Citation: Aslanoglou, K., Zygouris, N. C., Tsermentseli, S., Beazidou, E., & Xenakis, A. (2025). Utilizing educational robotics in elementary school to foster problem-solving skills and enhance the teaching of history. *Pedagogical Research, 10*(1), em0231. https://doi.org/10.29333/pr/15680

ARTICLE INFO

Received: 24 Jun. 2024

Accepted: 08 Oct. 2024

ABSTRACT

The present pilot study outlines findings from a study that evaluated the efficacy of educational robots in enhancing children's cognitive skills and historical knowledge. Applying LEGO® Wedo 2.0, the study focused on typically developing nine-year-old students in a K-12 public school setting. The hypothesis posited that students using robotics would demonstrate better performance in history lessons compared to those taught using conventional methods. Results indicated that students exhibited improved performance in history lessons when engaged with educational robotics, alongside a greater enjoyment of the subject compared to standard teaching methods. This study aligns with existing research suggesting that robotics can significantly impact education, serving as a tool to enhance students' cognitive skills.

Keywords: educational robotics, history lesson, teaching methods, cognitive skills, LEGO® Wedo 2.0

INTRODUCTION

Scientific and technological innovation in the 21st century requires the acquisition and development of new skills. These abilities include thinking, problem solving, decision making, learning and creativity, which are intertwined with the use of information communication technology (ICT) (Binkley et al., 2012). The widespread use of ICT tools in everyday life offers new opportunities for pedagogy, including innovations in teaching and learning methods (Demertzi et al., 2018; Redecker & Johannessen, 2013). Moreover, technology not only supports the effectiveness of the teaching-learning process, but also develops the learning process itself, including students' skills and abilities (Kálózi-Szabóet al., 2022; Xefteris & Palaigeorgiou, 2019).

In recent years, the research community has shown great interest in educational robotics (ER) as a technology that essentially promotes the educational process (Aslanoglou et al., 2018; Dolezal et al., 2018; Fanchamps et al., 2021; Zygouris et al., 2017a) and which offers significant benefits to learning and teaching (Ching et al., 2019; Kyriazopoulos et al., 2022; Mutseekwa et al., 2024). ER is a field that combines aspects of computer science, technology, engineering, art, and mathematics (STEAM) to teach students important skills while engaging them in hands-on, interactive learning experiences (Alimisis, 2013; Vicente et al., 2021). It is worth mentioning that ER is a tool to motivate students in the teaching and learning process (Arís & Orcos, 2019). ER helps students develop a wide range of skills, such as problem solving, critical thinking, creativity, collaboration, communication and computational thinking (Alimisis, 2013; Gratani et al., 2021). In addition, it enables exploration, design, modeling, programming and construction while at the same time it can support individual and collaborative learning activities (Romero & Dupont, 2016).

Cognitive skills are mental processes involved in acquiring, understanding, and using knowledge. These functions enable individuals to perceive, think, reason, remember, and solve problems. Research protocols suggests that cognitive skills can be enhanced by the use of ER and thus promote the overall cognitive development of students (Gabriele & Bilotta, 2013; Gabriele et al., 2017; Kálózi-Szabó et al., 2022; Liu et al., 2023; Moschella & Basso 2020; Romero & Dupont, 2016). The cognitive skills that can advance via the use of ER are problem-solving skills, thinking strategies and acquisition of new concepts (Gabriele et al., 2017). More specifically, ER often involves designing, building, and programming robots to perform specific tasks and solve problems Afari & Khine, 2017; Mutseekwa et al., 2024; Zhang & Zhu, 2022). This has the effect of enhancing critical thinking and problem-solving skills, which are essential cognitive functions (Zhang, 2024).

Studies indicate that students, using planning and sequencing, improve their ability to think logically and systematically and cultivate their working memory (Araujo et al., 2019; Fatourou et al., 2018; Moschella & Basso, 2020; Zhang & Zhu, 2022). This results in the development of critical thinking and metacognition, specifically the active control of the cognitive processes involved in learning (Moschella & Basso, 2020). Building and manipulating robots cultivates students' spatial and visualization skills that are useful for various cognitive tasks (Kálózi-Szabó et al., 2022). During robotics it is necessary for students to maintain their attention and stay away from external distractions so that they can complete their work. It has been established that ER attracts and maintains students' attention and interest in the learning process (Bravo Sánchez et al., 2017; Kálózi-Szabó et al., 2022). Developing sustained attention and focus supports overall cognitive skills and academic performance. Naturally, activities using robots significantly enhance motivation to learn (Ching et al., 2019).

In summary, ER can have a profound impact on cognitive skills such as problem solving, sequential thinking, spatial awareness, memory, attention, creativity, and feedback processing. By participating in hands-on robotics activities, students not only learn about robotics but also develop a wide range of cognitive skills that can be applied to various academic disciplines and real-world settings.

The main aim of this research protocol is to compare students' achievements in history knowledge when using ER versus standard teaching methods. This study aims to determine how ER enhances the learning of history, which requires memory and problem-solving abilities. It seeks to build on existing research regarding the use of ER in classrooms and its impact on these cognitive skills. The first hypothesis posits that students taught history with ER will perform better, indicating improved memory and problem-solving skills compared to those taught using standard methods. The second hypothesis suggests that students will have a more positive attitude towards ER than towards standard teaching methods.

METHOD

Participants

A total of 19 students (N = 19) (12 girls and 7 boys) studying at the third class of primary school (K-12) participated in the present pilot study. All students were of typical development, without history of serious medical illness, psychiatric disorder, developmental disorder, or significant visual or auditory impairment according to their medical reports available at their school. It is worth noting that none of the participants had ever followed any program using ER before and during their participation in the study. The students were divided into four groups, three groups consisted of five students and the fourth group consisted of four. Each team was asked to build a robot (humanoid robot "Homer", 2 ships and the Trojan Horse) and then program it with the appropriate commands, so that it would make the necessary movements on the map, according to the events of Trojan War (**Figure 1).** It is worth noting that all participants' parents/guardians had to sign the consent form, allowing their child to participate in the study. Finally, the present study was conducted in compliance with the Declaration of Helsinki and the guidelines of the University of Thessaly Internal Research Ethics Committee.

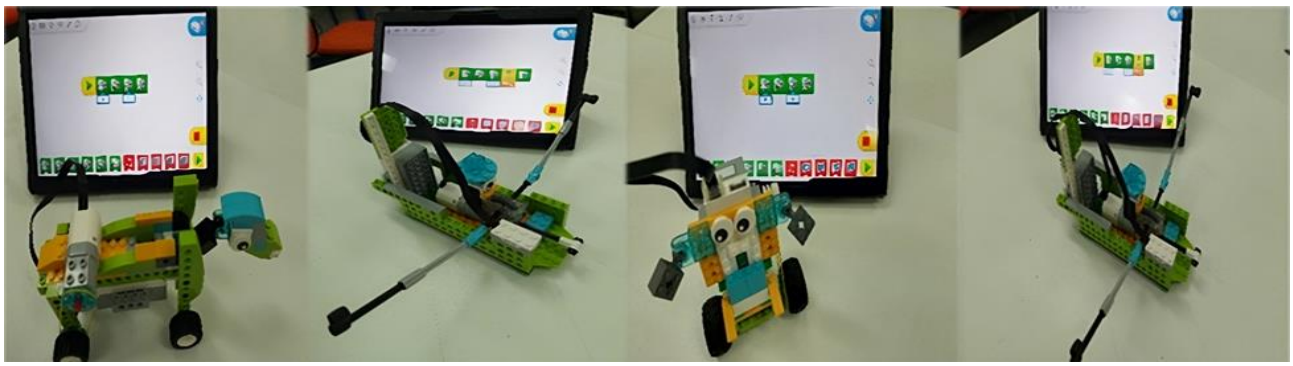

Figure 1. Robots and their programming (Source: Field study)

Tools

The LEGO® Wedo 2.0 ER package was used to carry out the research, which includes sorting trays, labels, a brain (Smarthub), a mid-motor, a motion sensor, a tilt sensor and enough additional materials for the students. Its software is supported by desktops and tablets and provides an easy-to-use programming environment (**Figure 2**). The student groups were given instructions to build the four robots. Then the students, under the guidance of their teacher, used the command blocks (images) to control the movements of the robots (speed, direction and duration of movement). Also, a mock-up with the map of Greece was used to move the robots, figures created by the students depicting the historical figures and picture cards that presented the events that happened.

The performance of the students as well as the enhancement of their cognitive functions were evaluated by administering an achievement test and a questionnaire using five-point Likert scale. In addition, throughout the research, students' attitudes towards ER were also assessed. The achievement test consisted of six tasks related to the events of the Trojan War (rhyme, filling in the blanks, ordering the characters of the story, one closed-ended question exercise and two open-ended questions). The questionnaire, administered alongside the achievement test, included two questions about their contentment with using robots

in teaching compared to standard teaching methods. Students were asked to indicate their liking of the teaching on a scale from 1 to 5 (where 1 = not at all, 2 = a little, 3 = quite a bit, 4 = a lot, and 5 = very much).

Use of ER in Teaching History

All the students were taught the events of the Trojan War in a typical way by the class teacher. The standards teaching methods involved the simple presentation of the lesson without interactive ways of learning. After completing the typical teaching method all children were assessed with six questions on the topic of the lesson. At the second meeting held after two months, the students encountered the ER equipment, learned the parts that make up the LEGO® Wedo 2.0 robotic kit and what their use is (**Figure 2**). In the third meeting the students, divided into groups, were asked to follow instructions to build the four robots related to the events of the Trojan War. In the fourth session, the students finished building the robots and were later taught the commands to program the robots (**Figure 1**). Of course, this was followed by experimentation and testing with the programming blocks to understand how ER works. In the next meeting, figures that participated in the story of Troy were made using simple everyday materials in order to join the teaching using ER (**Figure 3**). In the sixth and seventh meeting, the events of the Trojan War were reenacted using all the tools (robots, figures, map and cards). Using the map, the students, divided into groups according to the robot they had built, read the cards that narrated the events, programmed the robots to take the corresponding routes on the map, used the figures and role-played (**Figure 4**). The use of the robots and their programming played a key role in the teaching, as the Homer robot narrated the events in each area, the robot ships moved to get to Troy, and the Trojan Horse robot had to act out the events. In the last meeting, the final evaluation was carried out, which was the same as the initial one so that the results are accurate and objective. That is, students were given the same achievement test (six comprehension questions of the history lessons) combined with a questionnaire that included two questions related to their contentment using ER. It is worth noting that during the implementation of the research the students were provided with support, whenever deemed necessary, without limiting their ingenuity and self-motivation.

Figure 2. First contact with LEGO® Wedo 2.0 (Source: Field study)

Figure 3. Figures of the Trojan War for role play (Source: Field study)

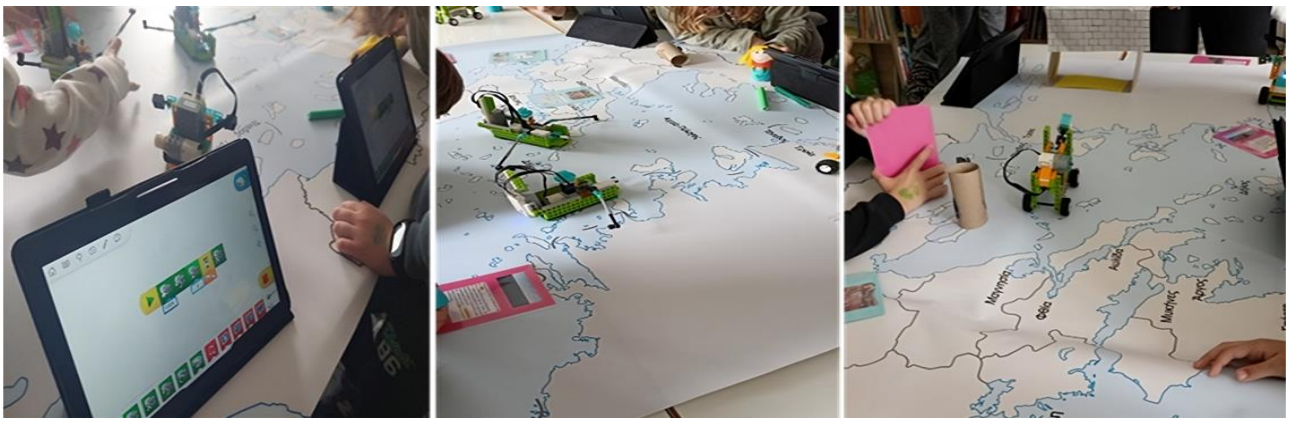

Figure 4. Teaching the Trojan War with the robot, map, cards, and role play (Source: Field study)

RESULTS

To compare the scores and the mean of these participants before and after use of ER in teaching history statistical package for social sciences, SPSS, 27.0 (IBM), and more specifically, a parametric statistical analysis, the paired sample t-test, was used. The paired sample t-test was conducted to compare the performance and cognitive skills of the typically developing participants before and after the survey where the ER was implemented.

Table 1 presents the average of the questions before and after using ER. Children presents more correct answers after implementing the ER teaching method in all 7 tasks in comparison to their performance after the standard teaching method. Also, as can be seen the t value is negative as the scores on the questions after using robotics were higher compared to the first questions taken before the survey.

Table 1. Mean scores and standard deviations of correct answers of students pre- and post-using ER

Exercises	Pre-using ER		Post-using ER		t
	Mean	Standard deviation	Mean	Standard deviation	
Acrostic	5.21	2.720	6.16	2.340	-3.149*
Fill in the blanks	8.53	4.260	9.68	3.010	-1.819
Sorting faces	6.68	4.280	8.05	3.410	-1.580
Exercise with closed type questions	6.42	2.670	8.68	1.860	-4.575*
Open-ended question about the apple of eris	16.05	12.310	26.84	7.490	-4.562*
Open-ended question about the sacrifice of iphigenia	10.53	11.654	20.26	10.603	-4.276*
Total of exercises	54.53	29.209	79.68	18.324	-5.995*

Note: *p < 0.01

As it is presented in **Table 1**, all participants presented statistically significant better performance after implementing the ER methodology in five out of seven tasks. However, in “fill in the blanks” and “sorting faces” tasks participants presented better scores, but with no statistical significance (p > 0.05) in comparison to their answers after the standard teaching method. It must be noted that the negative t scores are reported as all participants scored lower at the pre-using ER procedure in comparison to the post-using ER procedure.

Regarding the students’ contentment of using ER compared to standard teaching methodology the results are presented in **Table 2**.

Table 2. Mean scores and standard deviations of participants’ pre- and post-using ER contentment scores

	Pre-using ER		Post-using ER		
	Mean	Standard deviation	Mean	Standard deviation	t*
Contentment	2.47	1.124	4.84	.375	-6.889*

The statistical results, of **Table 2** collectively, reflect positive outcomes for the program using ER. So, it is perceived that indeed the use of ER as well as the intensity of elements of STEAM education helped the participants to develop their cognitive skills and improve their performance in the history lesson, since the learning was carried out in a more interactive and pleasant way by focusing their interest and attention in comparison to standard teaching method. Negative t scores revealed that all participants presented lower scores of satisfaction following standard teaching method in comparison to ER teaching method.

DISCUSSION

The present study was conducted to compare students’ history lesson performance and cognitive skills development before and after the implementation of ER. The results presented suggest that the use of LEGO® Wedo educational kits improved the participants’ achievement test scores. In more detail the results of the present study suggest that participants understood the lesson better but at the same time improved their cognitive functions. Furthermore, the children’s improved scores after the

application of robotics in all seven story assessment tasks in comparison to their performance following the typical teaching method. However statistically significant differences ($p < 0.01$) presented 5 out of 7 tasks. In tasks "fill in the blanks" and "sorting faces" participants presented better scores, but with no statistical significance ($p > 0.05$) in comparison to their answers after the standard teaching method. These results verify our first hypothesis that students with ER instruction would show better performance compared to standard instruction.

The results of the present research are in line with studies that use the same robotic package to improve their performance in courses. The same results were found in studies using LEGO® Wedo (Ajlouni, 2023; Araujo et al., 2019; Aslanoglou et al., 2018; Chalmers, 2018; Chiazzese et al., 2019; Romero & Dupont, 2016; Scaradozzi et al., 2015; Usengül & Bahçeci, 2020) and in those using LEGO® Go Mindstorms (Afari & Khine, 2017; AlQarzaie & AlEnezi, 2022; Chaudhary et al., 2016; Eteokleous & Ktoridou, 2014; Masril et al., 2021; Zygouris et al., 2017b). However, the research protocol of Moschella and Basso (2020) presented contradictory results, according to which while the same tool was used there was no significant variability in terms of student performance.

In addition, the present research evaluated the contentment and pleasure of students during teaching with ER compared to traditional teaching. The results of the present study suggest that children found statistically significant ($p < 0.001$) the ER methodology more pleasure joyful in comparison to typical teaching These results also verify the second hypothesis of the present study. It is important to mention that participants proved to maintain their attention for a longer period of time, were motivated to learn and tried through robotics to learn the rules of programming, thus developing their computational thinking.

The present study also supports the results of other studies that assessed cognitive skills through programs using ER. More specifically, the study by Chin et al. (2014) found evidence that robotics-based instruction made students learn better, focused more, and was also shown to attract and maintain interest and attention to the learning experience. The findings of research suggested that the use of ER in teaching helped to develop creative thinking, critical thinking and metacognition and additionally improved visuospatial and logical skills (Moschella & Basso, 2020). In another study it became clear that students were motivated to learn and at the same time improvement in reading, comprehension and spatial orientation skills was observed (Kálózi-Szabó et al., 2022; Zygouris et al., 2017a). Consequently, it became apparent that through ER students over time developed their computational skills, which included visuospatial working memory and logical and abstract reasoning skills. Also, in this research it was shown that children perceived ER activities as games and thus learning was engaging and fun. Of course, in all these activities they were rarely distracted while there was increasing motivation to learn (Liu et al., 2023). Of course, there were also studies with conflicting results regarding the enhancement of attention, since the use of robotics failed to show that it helped maintain attention (Di Lieto et al., 2017). and yet no difference was observed in selective and focused attention (Kálózi-Szabó et al., 2022).

In reviewing the findings of this research, the reader should bear in mind some of the study's methodological limitations. Firstly, although the sample size ($N = 19$) in the current research protocol is relatively small, the statistically significant findings align with the results of previous studies. Secondly, students had limited time to interact with the ER due to the strict school curricula, which restricted the use of additional school hours. Future research aims to apply the study to a larger sample, including students with special educational needs, to draw comprehensive conclusions about the use of ER across different learning levels. Additionally, it would be beneficial to implement simultaneous teaching, using both standard teaching methods and ER concurrently.

CONCLUSION

Despite limitations, the findings presented here can contribute to advancing existing knowledge and providing valuable insights for practitioners and researchers in this specific research domain. This study reaffirms previous findings documented in the relevant literature while also strengthening the existing body of knowledge with new insights. It demonstrates the effectiveness of integrating ER into history courses, enhancing students' performance and fostering the development of cognitive skills. Hence, our results indicate that combining storytelling and robotics could serve as an effective and sustainable approach to promoting the memory acquisition and problem-solving skills of children in education.

Author contributions: KA: principal investigator, validation, methodology, writing – original draft; **NZ:** supervision, data curation, methodology, writing – original draft; **ST:** supervision, project administration, writing – original draft, data curation. **EB & AX:** review and correction. All authors agreed with the results and conclusions.

Funding: No funding source is reported for this study.

Ethical statement: The authors stated that the study was performed in compliance with the Helsinki Declaration and the guidelines of the Ethics and Deontology Committee of the University of Thessaly. This study was approved by the Internal Research Ethics Committee of the Department of Computer Science and Telecommunications at the University of Thessaly with protocol code 227092023. Written informed consents were obtained from the participants.

Declaration of interest: No conflict of interest is declared by the authors.

Data sharing statement: Data supporting the findings and conclusions are available upon request from the corresponding author.

REFERENCES

Afari, E., & Khine, M. (2017). Robotics as an educational tool: Impact of lego mindstorms. *International Journal of Information and Education Technology, 7*(6), 437-442. https://doi.org/10.18178/ijiet

Ajlouni, A. (2023). The impact of instruction-based LEGO® Wedo 2.0 robotic and hypermedia on students' intrinsic motivation to learn science. *International Journal of Interactive Mobile Technologies, 17*(1), 22-39. https://doi.org/10.3991/ijim.v17i01.35663

Alimisis, D. (2013). Educational robotics: Open questions and new challenges. *Themes in Science and Technology Education, 6*(1), 63-71.

AlQarzaie, K. N., & AlEnezi, S. A. (2022). Using LEGO MINDSTORMS in primary schools: Perspective of educational sector. *International Journal of Online & Biomedical Engineering, 18*(1), 139-147. https://doi.org/10.3991/ijoe.v18i01.27579

Araujo, V., Mendez, D., & Gonzalez, A. (2019). A novel approach to working memory training based on robotics and AI. *Information, 10*(11), Article 350. https://doi.org/10.3390/info10110350

Arís, N., & Orcos, L. (2019). Educational robotics in the stage of secondary education: Empirical study on motivation and STEM skills. *Education Sciences, 9*(2), Article 73. https://doi.org/10.3390/educsci9020073

Aslanoglou, K., Papazoglou, T., & Karagiannidis, C. (2018). Educational robotics and down syndrome: Investigating student performance and motivation. In *Proceedings of the 8th International Conference on Software Development and Technologies for Enhancing Accessibility and Fighting Info-Exclusion* (pp. 110-116). https://doi.org/10.1145/3218585.3218600

Binkley, M., Erstad, O., Herman, J., Raizen, S., Ripley, M., Miller-Ricci, M., & Rumble, M. (2012). Defining twenty-first century skills. In E. Care, P. Griffin, & M. Wilson (Eds.), *Assessment and teaching of 21st century skills* (pp. 17-66). https://doi.org/10.1007/978-94-007-2324-5_2

Bravo Sánchez, F., González Correal, A., & Guerrero, E. (2017). Interactive drama with robots for teaching non-technical subjects. *Journal of Human-Robot Interaction, 6*(2), pp. 48-69. https://doi.org/10.5898/JHRI.6.2.Bravo

Chalmers, C. (2018). Robotics and computational thinking in primary school. *International Journal of Child-Computer Interaction, 17*, 93-100. https://doi.org/10.1016/j.ijcci.2018.06.005

Chaudhary, V., Agrawal, V., Sureka, P., & Sureka, A. (2016). An experience report on teaching programming and computational thinking to elementary level children using lego robotics education kit. In *Proceedings of the 2016 IEEE 8th International Conference on Technology for Education* (pp. 38-41). IEEE. https://doi.org/10.1109/T4E.2016.016

Chiazzese, G., Arrigo, M., Chifari, A., Lonati, V., & Tosto, C. (2019, October). Educational robotics in primary school: Measuring the development of computational thinking skills with the bebras tasks. *Informatics, 6*(4), Article 43. https://doi.org/10.3390/informatics6040043

Chin, K.-Y., Hong, Z.-W., & Chen, Y.-L. (2014). Impact of using an educational rbot-based learning system on students' motivation in elementary education. *IEEE Transactions on Learning Technologies, 7*(4), 333-345 https://doi.org/10.1109/TLT.2014.2346756

Ching, Y.-H., Yang, D., Wang, S., Baek, Y., Swanson, S., & Chittoori, B. (2019). Elementary school student development of STEM attitudes and perceived learning in a STEM integrated robotics curriculum. *TechTrends, 63*, 590-601. https://doi.org/10.1007/s11528-019-00388-0

Demertzi, E., Voukelatos, N., Papagerasimou, Y., & Drigas, A. S. (2018). Online learning facilities to support coding and robotics courses for youth. *International Journal of Engineering Pedagogy, 8*(3), 69-80. https://doi.org/10.3991/ijep.v8i3.8044

Di Lieto, M., Inguaggiato, E., Castro, E., Cecchi, F., Cioni, G., Dell'Omo, M., Laschi, C., Pecini, C., Santerini, G., Sgandurra, G., & Dario, P. (2017). Educational robotics intervention on executive functions in preschool children: A pilot study. *Computers in Human Behavior, 71*, 16-23. https://doi.org/10.1016/j.chb.2017.01.018

Dolezal, D., Posekany, A., Roschger, C., Koppensteiner, G., Motschnig, R., & Pucher, R. (2018). Person-centered learning using peer review method–an evaluation and a concept for student-centered classrooms. *International Journal of Engineering Pedagogy, 8*(1), 127-147. https://doi.org/10.3991/ijep.v8i1.8099

Eteokleous, N., & Ktoridou, D. (2014). Educational robotics as learning tools within the teaching and learning practice. In *Proceedings of the 2014 IEEE Global Engineering Education Conference* (pp. 1055-1058). IEEE. https://doi.org/10.1109/EDUCON.2014.6826237

Fanchamps, N., Slangen, L., Hennissen, P., & Specht, M. (2021). The influence of SRA programming on algorithmic thinking and self-efficacy using Lego robotics in two types of instruction. *International Journal of Technology and Design Education, 31*, 203-222. https://doi.org/10.1007/s10798-019-09559-9

Fatourou, E., Zygouris, N. C., Loukopoulos, T., & Stamoulis, G. I. (2018). Teaching concurrent programming concepts using Scratch in primary school: Methodology and evaluation. *International Journal of Engineering Pedagogy, 8*(4), 89-105. https://doi.org/10.3991/ijep.v8i4.8216

Gabriele, L., & Bilotta, E. (2013). Robot for thinking: Cognitive strategies to experiment the use of educational robotics in classroom. In *Proceedings of the EDULEARN13* (pp. 5801-5810). IATED.

Gabriele, L., Marocco, D., Bertacchini, F., Pantano, P., & Bilotta, E. (2017). An educational robotics lab to investigate cognitive strategies and to foster learning in an arts and humanities course degree. *International Journal of Online Engineering, 13*(4), 7-19. https://doi.org/10.3991/ijoe.v13i04.6962

Gratani, F., Giannandrea, L., Renieri, A., & Annessi, M. (2021). Fostering students' problem-solving skills through educational robotics in primary school. In *Proceedings of the Educational Robotics International Conference* (pp. 3-14). Springer. https://doi.org/10.1007/978-3-030-77022-8_1

Kálózi-Szabó, C., Moha, K., & Cottini, M. (2022). Employing robotics in education to enhance cognitive development–A pilot study. *Sustainability, 14*(23), Article 15951. https://doi.org/10.3390/su142315951

Kyriazopoulos, I., Koutromanos, G., Voudouri, A., & Galani, A. (2022). Educational robotics in primary education: A systematic literature review. In *Research anthology on computational thinking, programming, and robotics in the classroom* (pp. 782-806). IGI Global.https://doi.org/10.4018/978-1-6684-2411-7.ch034

Liu, Y., Odic, D., Tang, X., Ma, A., Laricheva, M., Chen, G., Wu, S., Niu, M., Guo, Y., & Milner-Bolotin, M. (2023). Effects of robotics education on young children's cognitive development: A pilot study with eye-tracking. *Journal of Science Education and Technology, 32*, 295-308. https://doi.org/10.1007/s10956-023-10028-1

Masril, M., Ambiyar, A., Jalinus, N., Ridwan, R., & Hendrik, B. (2021). Robotic education in 21st century: Teacher acceptance of lego mindstorms as powerful educational tools. *Intenational Journal of Advence Computer Science and Applications, 12*(2), 119-126. https://doi.org/10.14569/IJACSA.2021.0120216

Moschella, M., & Basso, D. (2020). Computational thinking, spatial and logical skills. An investigation at primary school. *Ricerche di Pedagogia e Didattica. Journal of Theories and Research in Education, 15*(2), 69-89.

Mutseekwa, C., Dzavo, J., Musaniwa, O., & Nshizirungu, G. (2024). Framing pre-service teacher preparation in Africa from global STEM education practices. *Pedagogical Research, 9*(3), Article em0215. https://doi.org/10.29333/pr/14701

Redecker, C., & Johannessen, Ø. (2013). Changing assessment–Towards a new assessment paradigm using ICT. *European Journal of Education, 48*(1), 79-96. https://doi.org/10.1111/ejed.12018

Romero, M., & Dupont, Y. (2016). Educational robotics: From procedural learning to co-creative project oriented challenges with LEGO® Wedo 2.0. In *Proceedings of the EDULEARN16* (pp. 6159-6163). IATED. https://doi.org/10.21125/edulearn.2016.0318

Scaradozzi, D., Sorbi, L., Pedale, A., Valzano, M., & Vergine, C. (2015). Teaching robotics at the primary school: An innovative approach. *Procedia-Social and Behavioral Sciences, 174*, 3838-3846. https://doi.org/10.1016/j.sbspro.2015.01.1122

Usengül, L., & Bahçeci, F. (2020). The effect of LEGO® Wedo 2.0 education on academic achievement and attitudes and computational thinking skills of learners toward science. *World Journal of Education, 10*(4), 83-93. https://doi.org/10.5430/wje.v10n4p83

Vicente, F., Llinares, A., & Sánchez, N. (2021). Curriculum analysis and design, implementation, and validation of a STEAM project through educational robotics in primary education. *Computer Applications in Engineering Education, 29*(1), 160-174. https://doi.org/10.1002/cae.22373

Xefteris, S., & Palaigeorgiou, G. (2019). Mixing educational robotics, tangibles and mixed reality environments for the interdisciplinary learning of geography and history. *International Journal of Engineering Pedagogy, 9*(2), 82-98. https://doi.org/10.3991/ijep.v9i2.9950

Zhang, L. (2024). Blended pedagogy for computer programming language. *Pedagogical Research, 9*(3), Article em0218. https://doi.org/10.29333/pr/14744

Zhang, Y., & Zhu, Y. (2022). Effects of educational robotics on the creativity and problem-solving skills of K-12 students: A meta-analysis. *Educational Studies*. https://doi.org/10.1080/03055698.2022.2107873

Zygouris, N. C., Striftou, A., Dadaliaris, A. N., Stamoulis, G. I., Xenakis, A. C., & Vavougios, D. (2017a). The use of LEGO mindstorms in elementary schools. In *Proceedings of the 2017 IEEE Global Engineering Education Conference* (pp. 514-516). IEEE. https://doi.org/10.1109/EDUCON.2017.7942895

Zygouris, N. C., Vlachos, F., Dadaliaris, A. N., Oikonomou, P., Stamoulis, G. I., Vavougios, D., Nerantzaki, E., & Striftou, A. (2017b). A neuropsychological approach of developmental dyscalculia and a screening test via a web application. *International Journal of Engineering Pedagogy, 7*(4), 51-65. https://doi.org/10.3991/ijep.v7i4.7434